injectate density of 1.15 SG are depicted in Figure 4-3. The calculated plume after 30 years of continuous injection at 50 gpm is depicted in Figure 4-4. The plume depicted in Figure 4-4 is not circular and is larger due to the previous injection in the former WDW-117. The plume diameter is approximately 8,600 feet. As in the previous runs, the relative concentration contour, C/Co, of 0.001 defines the lateral extent of the plume. This demonstrates that the impact of previous injection is small and that the results given above for the two previous runs are very conservative and are likely to overestimate the extent of the waste in the subsurface.

4.3.5 Vertical Waste Movement Through Shale

From the WDW-394 electric log, there is approximately 35 feet of low permeability shale directly overlying the injection interval 2,955 to 3,000 feet BKB. Vertical waste movement was modeled through the shale using an advective component resulting from the pressure increase due to waste injection. The pressure increase was obtained from modeling presented in Section VII.A.6 of the WDW-394 permit application (Cook-Joyce, 2004). The calculated pressure increase was 111 psi at the well after 30 years of injection at 50 gpm. From this modeling, it was determined that there is no cone of influence for WDW-394.

To provide for a conservative model result for vertical waste movement, all of the historical flow from WDW-117 was input at the average rate for the period July 7, 1974 until April 4, 1994 when WDW-117 was taken out of service (total of 19.74 years). At that time in the model, a constant injection rate of 50 gpm was specified for 30 years future operation. At the end of injection, pressure at the well will decrease rapidly and eventually return to the initial pressure. An additional 15-year period at 50 gpm was added to account for the time in which pressure is decreasing in the reservoir. Therefore the total model time of injection was 19.74 years + 30 years + 15 years = 64.74 years. This is very conservative and insures that the advective component of transport is overestimated.

The advective component of transport can be found through Darcy's law written in terms of the total head gradient:

$$q = -K\frac{dh}{dl} = -K\frac{\Delta h}{\Delta l} \qquad (1)$$

where, $\frac{\Delta h}{\Delta l}$ = total head gradient

K = hydraulic conductivity of shale

The vertical shale permeability was assigned to be 1×10^{-4} millidarcys. Vertical permeabilities are commonly considered to be one tenth of the horizontal permeability. This value was derived from the range of values given in Freeze and Cherry (1979 p. 29) for shale. It is considered to be a representative value for shale in the Texas Gulf Coast. The shale porosity was assumed to be one half of the sand porosity or 0.10.

The vertical hydraulic conductivity (K) of the 35 feet thick shale directly overlying the injection interval is calculated as follows:

$$K_{shale\ vert} = \frac{(1 \times 10^{-4}\ \text{md})(61.97\ \text{lb/ft}^3)(86{,}400\ \text{sec/day})(1\ \text{darcy})(1.06\times10^{-11}\ \text{ft}^2/\text{darcy})}{(0.486\ \text{cp})(2.088\times10^{-5}\ \text{lb-sec/ft}^2\text{-cp})(1000\ \text{md})}$$

$$K_{shale} = 5.606 \times 10^{-7}\ \text{ft/day}$$

The total head gradient was defined in terms of pressure and elevation.

$$\frac{\Delta h}{\Delta l} = \frac{\frac{\Delta p}{\rho g} + \Delta z}{L} \qquad (2)$$

where,
L = distance
Δp = pressure change across distance L
ρg = fluid specific weight (density)
Δz = elevation change across L

The distance, L, and elevation change, Δz, are both equal to the thickness of the first shale sequence overlying the injection interval at Corsicana Technologies. The pressure change was calculated using the SWIFT model.

With a pressure gradient of 0.430347 psi/foot (based on 61.97 lb/ft^3 formation fluid density at 136° F), the initial pressure at the top of the injection interval at 2,955 feet BKB is 1,120 psi. Using the same gradient, the initial pressure at the top of the 35 feet thick shale is 1,105 psi (1,120 psi – (35 feet)(0.430347 psi/ft)). Therefore, the pressure differential at the top of the shale unit overlying the injection interval is 126 psi (111 psi injection pressure + (11,120 psi – 1,105 psi)).

The hydraulic gradient is calculated as:

$$dh/dl = \frac{\frac{(\Delta p)_{INJ}}{\rho g} + \Delta z}{L}$$

$(\Delta p)_{INJ}$ = injection pressure differential = 126 psi

ρg = formation fluid density (136 °F) = 61.97 lb/ ft^3/144 in^2/ft^2
= 0.430347 psi/ft

L = thickness of first shale sequence overlying the injection interval = 35 feet

Δz = 35 feet

dh/dl = 9.37 feet/feet

The vertical Darcy velocity through the first shale sequence overlying the injection interval is:

$$q = -K \frac{\Delta h}{d l}$$

$$q = 5.60 \times 10^{-7} \text{ ft/day } (9.37)$$

$$= 5.25 \times 10^{-6} \text{ ft/day}$$

The vertical average linear velocity was determined by dividing the Darcy velocity by the shale porosity (0.10):

$$v = (5.25 \times 10^{-6} \text{ ft/day})/(0.10)$$

$$= 5.25 \times 10^{-5} \text{ ft/day}$$

The total vertical advective transport was then calculated by applying the average linear velocity for the entire 64.74 year combined operational and post-operational period (49.74 year operational period and 15-year post-operational fall-off period) in which injection interval pressure was elevated due to injection operations.

The total advective transport distance of waste into the first containing shale sequence overlying the injection interval is:

$$\text{Advective vertical transport} = v \cdot t \qquad (3)$$

$$\text{Advective vertical transport} = (5.25 \times 10^{-5}\ \text{ft/day})(64.74\ \text{yr})(365.25\ \text{day/yr})$$

$$\text{Advective vertical transport} = 1.24\ \text{feet}$$

The calculated vertical waste transport distance is conservative since the pressure increase was applied to the injection interval during the entire operational period, and a conservative shale permeability was assigned. The result is an over-estimated vertical waste transport distance.

5.0 SITE SPECIFIC DATA

As noted in Section 2.0, CTI applied to the TCEQ on July 20, 2001 for a new permit to construct and operate an underground injection well for the disposal of industrial, nonhazardous waste; a permit to install the injection well was granted on 3 September 2004. The permit application and subsequent revisions dated 10 June 2002 and 16 August 2002 (hereinafter referred to as the permit application) contain site-specific information and detailed supporting data. Pertinent application information and supporting data are referenced and summarized below in support of this aquifer exemption request.

As presented in Section 3.0 of this request, site-specific conditions must comply with the two criteria of 30 TAC §331.13(c) in order to qualify for the designation of an exempt aquifer. The first of these criteria specifies that the aquifer or portion of the aquifer for which an exemption is being sought cannot currently serve as a source of drinking water for human consumption. The portion of the Woodbine aquifer addressed by this petition is not currently a source of drinking water for human consumption, as discussed in Section 5.1, below. The second of these criteria specifies that the aquifer or portion of the aquifer for which an exemption is being sought cannot represent a future source of drinking water. Section 5.2 addresses the specified conditions under which an aquifer can be exempted as a future source of drinking water.

5.1 CURRENT AQUIFER USE

To evaluate the production and use of groundwater from the Woodbine in the project area, a literature review and file search of the Texas Water Development Board and the Texas Natural Resource Conservation Commission records was conducted to support the permit application. The results of that file search are shown in Appendix V-C of the permit application. A review of the TWDB Report 160, *Ground-Water Resources of Navarro County, Texas*, was also conducted as part of the original permit application to identify all the wells drilled and reported in the County through 1987. Of the wells identified through the water well search and TWDB Report 160, only one has been completed into the Woodbine Formation within the 2.5-mile area of review (AOR). This well is identified as the W.E. Butler, Roberts Well and was completed in 1949 to a depth of 2,592 feet. For the purpose of this aquifer exemption request, the public records search has been updated to determine if any additional water wells have been recorded since the date of the original search. A copy of the recent search is included as Appendix A. No additional wells were identified within the AOR as a result of the more recent record search.

In addition to review of published well information, interviews were conducted with operators of oil and gas fields in the vicinity of the CTI facility. Based on these interviews, it appears that there were two Butler wells. The second well (Butler 2) was located approximately 500 feet to the east of the Butler 1 well as depicted in Figure 4-1, and was reported to have been drilled to the same depth as the Butler 1 well. Both wells were reported to have been used to supply water for the flooding of an oil-producing zone in Nacatoch Sand, which is located above the proposed injection zone in the Woodbine formation. Groundwater produced from the wells was not used for human consumption. Although there were no plugging records for the two Butler wells, they are both believed to have been decommissioned based on conversations with local operators.

Two additional wells that are completed into the Woodbine within the AOR, the Gray well and the Crown well, were identified through discussions with a local land owner and a Field Superintendent of Rife Oil. The locations of these wells are shown on Figure 4-1. The Gray well is located approximately 5,000 feet to the southwest of the WDW-394 location. The Crown well is located on the former Crown Oil Property which is approximately an eighth of a mile to the east of the Gray well. These wells were also reported to have been used to supply water for flooding of oil producing zones. The Gray well had not been used for the 15 years prior to the 2002 interview. The Field Superintendent reported that the Crown well was drilled and completed similarly to the Gray well and a geophysical log of the well was on file at their office. The Rife representative granted permission to collect a groundwater sample from each of the Crown and Gray wells.

Therefore, based on this information, there are only two wells currently completed into the Woodbine within the AOR, and the Woodbine is not currently and was not previously used as a source of drinking water for human consumption.

5.2 FUTURE AQUIFER USE

As noted in Section 3.0, the second regulatory criteria specifies that the aquifer or portion of the aquifer for which an exemption is being sought cannot represent a future source of drinking water due to at least one of four specified conditions. Of these four conditions, two relate to mineral or energy resource production and two relate to economic or technical impracticality for drinking water production. These conditions are discussed below.

5.2.1 Mineral or Energy Resource Production

Two conditions under which an aquifer would not represent a future USDW are: (1) the formation is mineral, hydrocarbon or geothermal energy bearing with production capability; or (2) the formation is located above a Class III well mining area subject to subsidence or catastrophic collapse. The requested aquifer exemption is not located above a Class III well mining area and the aquifer does not constitute a mineral resource; however, the Woodbine does represent a potential energy resource, as discussed below.

As presented in Appendix V-B of the permit application, an interpretation of the electric log of the former Jetco injection well indicates that there is a 4-foot oil show on the top of the Woodbine Formation. However, in the area of the CTI site, this show is not currently believed to be a commercial oil play. Accordingly, the Woodbine is not believed to represent a hydrocarbon bearing zone with production capability.

Also as noted in the permit application, the U.S Department of Energy (DOE) constructed a geothermal production well into the Woodbine Formation at Navarro College, which is located to the west of the AOR. Based on testing of the well, the DOE concluded that:

- The Central Texas geothermal resource near Corsicana can produce large quantities of relatively clean geothermal waters having temperatures at approximately 130°F and it is capable of supporting additional geothermal development.

- This project has demonstrated that substantial energy savings can be achieved for geothermal systems addressing water and space heating loads, even in mild Texas climates.

A copy of the U.S. Department Of Energy report, *Direct Utilization of Geothermal Heat In Cascade Application To Aquaculture & Greenhouse Systems at Navarro College*, September 1984 is provided as Appendix B.

As part of the search of water well records of Navarro County, an additional Woodbine geothermal well was identified in Corsicana that is located outside of the AOR. The City drilled the well in 1895 to a depth of 2,515 feet. A sample result from 1938 indicated that the temperature of the groundwater was 120°F. A note in the well report file indicates the well was used to fill a pool at a natatorium. After the natatorium closed, the well was destroyed in 1948. A copy of the well report is provided as Appendix C.

The geophysical log of injection well WDW-394 recorded a bottom hole temperature of 141°F. A copy of the geophysical log is presented as Appendix D.

Based on the records from the two past geothermal wells in the area the associated DOE report, as well as the bottom hole temperature recorded for WDW-394, groundwater from the Woodbine Formation is capable of producing geothermal energy, and therefore does not represent a future source of drinking water consumption.

5.2.2 Economic or Technologic Impracticality for Drinking Water Production

Currently, the City of Corsicana acquires water from Lake Halbert and Navarro Mill Lake and treats it by conventional flocculation-sedimentation-chlorination. As discussed herein, the chemical characteristics of the lower Woodbine Formation would necessitate treatment (carbon adsorption and reverse osmosis are anticipated to be necessary) prior to distribution as publicly-supplied drinking water. The additional energy cost to pump from approximately 2,500 feet deep plus the use of carbon treatment and reverse osmosis represents significant additional treatment costs that make production of the Woodbine water "economically impractical to render that water fit for human consumption", while suitable surface water sources are available that can be treated for consumption through conventional means.

A well completed in the Woodbine Formation for domestic use would require a completion method that would isolate the oil producing Nacatoch Sand and the upper sand of the Woodbine from the lower sands of the Woodbine.

The Woodbine Formation outcrops to the west of Navarro County and dips to the east-southeast. With distance from the outcrop/groundwater recharge zone of the Woodbine, the groundwater becomes more mineralized. Based on data presented in TWDB Report 160, *Ground-Water Resources of Navarro County, Texas*, groundwater from the Woodbine in the western third of Navarro County is produced for domestic, stock, industrial, and public-supply uses. The groundwater is reported to be slightly saline (1,000 to 3,000 ppm TDS) in this area of the county. Approximately 12 miles to the west of the CTI facility the TWDB has identified the boundary of slightly saline – saline groundwater (3,000 to 10,000 ppm TDS) at an approximate depth of 1,600 feet below ground level. Navarro College, located approximately 5 miles to the west of the CTI facility, constructed a well into the Woodbine Formation for geothermal use in the 1980's. The TDS measurements of groundwater from this well were reported to be approximately 6,000 ppm at a depth of approximately 2,500 feet below ground level. Figure 5-1 is a contour map of the total dissolved solids in the Woodbine Formation.

Groundwater samples have been collected from the Gray and Crown wells and WDW-394. On 24 and 25 September 2002 groundwater samples were collected from the Gray and Crown wells, respectively. Groundwater samples were collected from the WDW-394 on 30 May 2005 and 7 February 2006.

Prior to purging the Gray and Crown wells, groundwater samples were also collected from the top 3 feet of the water column in each well. The pre-purge samples (Gray 1 and Crown 1) were collected using new PVC bailers. These samples were analyzed for total petroleum hydrocarbons (TPH). The bailers were coated with a petroleum material as a result of the sampling activities. The Gray 2 and Crown 2 samples were collected after purging the wells.

The three wells were purged and groundwater was monitored in the field for temperature, pH and conductivity during pumping. However, due to an equipment malfunction, conductivity measurements were not recorded during the purging of WDW-394. Stabilized field measurements were used to determine that the well had been sufficiently purged. The field measurements have been summarized in Table 5-1. The volume of purged water was also monitored. Approximately 3,875 gallons of groundwater were purged from the Gray well prior to the collection of the Gray 2 sample. Approximately 5,250 gallons of groundwater were purged from the Crown well prior to the collection of the Crown 2 sample. Approximately 7,000 gallons were purged from WDW-394 prior to the collection of the WDW-394 samples.

The analytical results from the sampling activities indicate that several constituents are present at concentrations exceeding EPA's primary and secondary drinking water standards. The results of the sampling events are summarized in Table 5-2. The laboratory reports from the sampling events are presented in Appendix E.

<u>Gray Well</u>

The analytical results from the Gray well groundwater sample indicate that seven constituents are present at concentrations that exceed EPA's drinking water standards. These constituents included gross alpha at 35 pci/L, gross beta at 106 pci/L, benzene at 0.01177 mg/L, barium at 2 mg/L, lead at 0.0841 mg/L, chloride at 11,200 mg/L, and TDS at 20,000 mg/L. In addition, TPH is present at a concentration of 101 and 78.9 mg/L in Gray sample 1 and 2, respectively. Although there is not a drinking water standard for TPH, the PCL under TRRP for the various aliphatic and aromatic chains range from 0.98 to 49 ppm. Constituents also identified but at concentrations below drinking water standards included toluene, xylenes, copper, and selenium. The sample was slightly turbid and a slight oil sheen was visible on top of the sample.

<u>Crown Well</u>

The analytical results from the Crown 2 sample indicate that seven constituents are present at concentrations that exceed EPA's drinking water standards. These constituents include gross alpha at 115 pci/L, gross beta at 78 pci/L, barium at 3.58 mg/L, chromium at 262 mg/L, lead at 0.25 mg/L, chloride at 2,820 mg/L, and TDS at 6,370 mg/L. TPH was not present in the sample collected after purging, however it was present at concentrations of 31.5 mg/L in the sample (Crown 1) collected from the top of the water column prior to purging. Although there is not a drinking water standard for TPH, the PCL under TRRP for the various aliphatic and aromatic chains range from 0.98 to 49 ppm. Constituents also identified at concentrations below drinking water standards include toluene, xylenes, copper, and sulfate. The discharge from the Crown well had a lime green color initially and after approximately 75 minutes changed to turquoise. The turquoise color continued through the remaining 75 minutes of purging.

Due to the unnatural color of the groundwater present in the Crown well and difference in the groundwater chemistry between the Crown well and the Gray well, which is located approximately 500 yards up-dip of the Crown well, it is believed that the sample collected from the Crown well is not representative of natural groundwater conditions in the Woodbine Formation.

WDW-394

The samples collected from WDW-394 in May 2005 were analyzed for TDS and ammonia as nitrogen. Due to sampling preservation techniques, the TDS results of this sampling event were not believed to be representative of aquifer conditions. During the second sampling event in February 2006, 10 samples were collected and analyzed for TDS and two of these samples were also analyzed for volatile organics compounds, semi-volatile organic compounds, RCRA metals, ammonia as nitrogen, cation/anions general chemistry constituents, and dissolved gases. A summary of the analytical results is presented in Table 5-2.

The analytical results from the WDW-394 sample indicate that three constituents are present at concentrations that exceed EPA's secondary standards drinking water standards. These constituents include TDS, fluoride, and chloride. The identified constituents also included 12 volatile and semi-volatile constituents at concentrations below drinking water standards. These constituents consist of: acetone, benzene, toluene, ethylbenzene, xylenes, isopropylbenzene, n-propylbenzene, naphthalene, 1,2,4-trimethylebenzene, 1,3,5-trimethylebenzene, ethane, and methane. Ammonia as nitrogen was also detected at relatively low concentrations in the two groundwater samples collected from WDW-394, which may indicate that the well is located within but near the edge of the plume from former Jetco injection well WDW-117.

A copy of the Jetco well-log interpretation, which states that a 4-foot oil show is present on the top of the Woodbine Formation, is presented in Appendix F. Appendix C is a copy of the City of Corsicana's water well record for the 1895 geothermal well. The record includes an analysis of a sample collected from the well.

Summary

Past sampling events of the three Woodbine wells in the area of the CTI facility indicate that nine constituents are present at concentrations that exceed primary or secondary drinking water standards which would make the use of groundwater from the Woodbine in the area of WDW-394 impractical for human consumption. The additional energy cost to pump from approximately 2,500 feet deep, plus the use of carbon treatment and reverse osmosis to treat the water to acceptable drinking water quality, represent significant additional treatment costs that make production of the Woodbine water "economically impractical to render that water fit for human consumption", while suitable surface water sources are available that can be treated for consumption through conventional means.

6.0 EXEMPT AQUIFER LIMITS

The horizontal limit of the requested exempt aquifer is within a 4,000 foot radius of the approximate center point of the plume from WDW-394. The limits of the requested exempt aquifer are defined vertically as the combined lowermost shale (called shale A) and the lowermost sand unit of the Woodbine Formation (called Sand A). The vertical limits of the lowermost units of the Woodbine Formation comprise the injection zone and are located at depths from 2,920 to 3,000 feet BKB based upon the WDW-394 logs. The interval from 2,920 to 2,955 feet BKB is the confining zone shale A. The interval from 2,955 to 3,000 feet BKB is the injection interval.

The structure of the upper limits of the injection zone is shown in Figure 6-1. The lower limit of the injection zone is bounded by the underlying Maness Shale of the Washita Group. Figure 6-2 is an isopach (thickness) map of the net sand in the lower Woodbine Sand A. From this figure, it is clear that Sand A is laterally extensive and correlative across the AOR and beyond. An isopach map of the confining Shale A is given in Figure 6-3. Shale A is also laterally continuous and correlative throughout the study area within and beyond the Area of Review. A stratigraphic column of the upper and lower Woodbine showing various sand and shale designations is given in Figure 6-4.

The horizontal limit of the proposed exempt aquifer is defined by the lateral extent of the injectate plume which may contain concentrations above drinking water standards. As discussed in Section 4.0, the horizontal extent of the plume radius is not projected to exceed 4,000 feet. The extent of the 4,000 foot radius from the approximate center point of the plume from WDW-394 (longitude 96°25'31", latitude 32°5'44") is shown on Figure 6-5.

7.0 CONCLUSIONS

Based on the site-specific data collected from the installation and sampling of WDW-394 and the historical data available from WDW-117, the following conclusions have been reached and support the requirements of 30 TAC 331.13 for the request for an aquifer exemption of the A sand unit of the Lower Woodbine Formation within a 4,000 foot radius of the WDW-394.

- The portion of the Woodbine aquifer addressed by this petition is not currently a source of drinking water for human consumption.
- The aquifer or portion of the aquifer for which an exemption is being sought does not represent a future source of drinking water.
- The DOE states that: "The Central Texas geothermal resource near Corsicana can produce large quantities of relatively clean geothermal waters having temperatures at approximately 130°F and it is capable of supporting additional geothermal development."
- The depth of the aquifer, the presence of the oil producing upper Nacatoch sands, the elevated TDS concentrations (>8,500 ppm) of the lower Woodbine Formation, the non-producible oil show in the upper Woodbine, the presence of constituents in the Woodbine Formation above drinking water standards, prior contamination of the aquifer by former injection from WDW-117, and the contamination detected in the Crown Well; renders the aquifer an economically and/or technologically impractical source of drinking water.

In addition, the requested 4,000-foot radius for the aquifer exemption (Figure 6-5) is at the predicted 1,000 times reduction in the plume concentration. As a result, impacts to groundwater beyond the proposed limits of the aquifer exemption due to the previous and future injection activities are predicted to be less than drinking water standards.

8.0 REFERENCES

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TABLES

TABLE 4-1
SUMMARY OF RESERVOIR PROPERTIES DERIVED FROM WELL TESTS IN THE WOODBINE FORMATION

Date	Test Type - Location	Permeability	Transmissivity	Skin	Comments
12/19/80	19 hour production at Navarro College (EAS, 1984)	449 md	36369 md-ft	0.0	h = 81 ft Q= 100 gpm Stor. = 2.4e-5 No boundaries reported
10/12/93	66 hour falloff WDW-117 (Envirocorp, 1993)	35 md	1890 md-ft	-2.4	ct = 6.9e-6 h = 54 feet visc. = 0.67 No boundaries reported.
11/12/92	Falloff WDW-117 (TWO, 1993)	210 md	1017 md-ft	-6.9	visc. = 0.65 h = 5.0 ft No boundaries reported.

TABLE 4-2
SUMMARY OF WDW-394 WHOLE CORE ANALYSIS FROM THE INJECTION INTERVAL

Core	Sample Number	Depth (feet)	Air Permeability (md)	Klinkenberg Permeability (md)	Porosity at 800 psi (%)
2	2-17	2955.50	5.63	4.30	14.7
2	2-18	2956.50	46.5	39.7	24.7
2	2-19	2957.40	35.3	29.7	23.7
2	2-20	2958.50	1.15	0.839	21.4
2	2-21	2959.45	204.	186.	25.2
2	2-22	2960.50	249.	229.	27.4
2	2-23	2961.50	449.	420.	27.4
2	2-24	2962.45	487.	455.	24.4
2	2-25	2963.50	624.	587.	27.2
2	2-26	2964.50	871.	826.	27.1
2	2-27	2965.15	292.	269.	25.8
2	2-28	2966.50	39.2	33.3	21.6
3	3-11	2979.50	497.	465.	26.7
3	3-12	2980.50	875.	829.	26.9
3	3-13	2981.50	0.0038	0.0010	3.7
3	3-14	2982.55	150.	135.	25.5
3	3-15	2983.45	0.0630	0.0330	17.0
3	3-16	2984.50	5.47	4.16	22.7
3	3-17	2985.65	84.2	74.0	18.0
3	3-18	2986.45	40.5	34.4	16.1
3	3-19	2987.50	322.	298.	28.1
3	3-20	2988.50	527.	494.	28.2
3	3-21	2989.55	0.0096	0.0034	4.1
3	3-22	2990.50	0.0032	0.0008	2.8
3	3-23	2991.50	-	-	-
3	3-24	2992.55	212.	193.	26.8
3	3-25	2993.50	456.	426.	25.7
3	3-26	2994.45	97.5	86.3	24.1
3	3-27	2995.50	0.340	0.234	16.0
3	3-28	2996.50	0.035	0.017	14.9
3	3-29	2997.50	0.464	0.333	18.7
3	3-30	2998.40	-	-	-
3	3-31	2999.40	0.0160	0.0066	12.9
4	4-1	2999.60	0.0120	0.0045	13.1
				Average 191.23 md	**Average 20.7%**

Source: Omni Laboratories, 2005

TABLE 4-3
FORMATION FLUID ANALYSIS FROM WDW-394 (DHL ANALYTICAL, 2006)

Sample Number	Total Dissolved Solids (mg/l)
1	8700
2	8550
3	8620
4	8570
5	8490
6	8550
7	8650
8	8390
9	8540
10	8730
AVERAGE	8579

TABLE 4-4
FORMATION FLUID AND INJECTATE VISCOSITY USED IN THE SWIFT MODELING

Temperature °F	Viscosity (cp)
	Formation Fluid
80	0.886
100	0.707
136	0.486
160	0.407
	Light Injectate (SG = 0.998 at 68° F)
80	0.864
100	0.686
136	0.479
160	0.393
	Heavy Injectate (SG = 1.15 at 68° F)
80	1.400
100	1.121
136	0.893
160	0.657

TABLE 4-5
SELECTIVE FORMATION TESTER RESULTS FOR WDW-394

Date	Log Depth (feet BKB*)	Sand	Pressure (psig)
5/30/2005	2982	A	1132
5/15/2005	2880	B	918
5/14/2005	2730	C	1026
5/14/2005	2590	D	965

*KB elevation is 401 feet ASL and the ground level elevation is 387 feet ASL.

TABLE 4-6
SUMMARY OF RESERVOIR PROPERTIES USED IN THE SWIFT MODELING

Property	Value	Source
Porosity	0.207	Omni Laboratories (2005)
Thickness	36 feet	Net sand of perforated interval from WDW-394 log
Sand Permeability	191 md	Omni Laboratories (2005)
Hydraulic Conductivity	1.071 feet/day	Calculated from permeability
Formation Fluid Compressibility	2.9×10^{-6} psi^{-1}	Earlougher (1977; Fig. D16)
Rock Compressibility	3.3×10^{-6} psi^{-1}	Earlougher (1977; Fig. D11)
Formation Fluid Viscosity	0.886 cp at 80° F 0.707 cp at 100° F 0.486 cp at 136° F 0.847 at at 160° F	Earlougher (1977; Fig. D35) 8,579 ppm NaCl
Low Density Injectate Viscosity	0.864 cp at 80° F 0.686 cp at 100° F 0.479 cp at 136° F 0.393 at at 160° F	Earlougher (1977; Fig. D35) 0.0 ppm NaCl
High Density Injectate Viscosity	1.400 cp at 80° F 1.121 cp at 100° F 0.893 cp at 136° F 0.657 at at 160° F	Earlougher (1977; Fig. D35) 204,000 ppm NaCl
Formation Fluid Density	61.97 lb/ft^3 at 137.6° F	8,579 ppm NaCl Numbere 1977
Light Injectate Density	62.316 lb/ft^3 at 68° F 61.61 lb/ft^3 at 137.6° F	0.0 ppm NaCl, Numbere 1977
Heavy Injectate Density	71.792 lb/ft^3 at 68° F 70.64 lb/ft^3 at 137.6° F	204,000 ppm NaCl Numbere, 1977
Bottomhole Temp. Gradient	0.021613° F/foot	Measurement WDW-394
Well Radius	0.23 feet (5.5 inch casing)	WDW-394 completion
Injection Rate	50 gpm	Permit Rate
Dispersivity	160 ft in x, 16 ft in y	Gelhar et al., (1992)
Molecular Diffusivity	9.89×10^{-3} ft^2/day	Einstein–Stokes Eqn. for arsenic
Initial Bottomhole Pressure	1120 psi at 2955 ft BKB	Precision Energy (2005)
Initial Bottomhole Temp.	141° F at 3,114 feet BKB	WDW-394 Electric Log

TABLE 4-7
COMPARISON OF PERFORATED INTERVALS IN WDW-117 AND WDW-394

WDW-117 Perforations (feet BKB)	WDW-117 Perforations (feet subsea)	Thickness (feet)	Sand	WDW-394 Perforations (feet BKB)	WDW-394 Perforations (ft subsea)
2790-2828	2393-2431	38	B Upper Woodbine		
2832-2844	2435-2447	12	B Upper Woodbine		
2926-2932	2529-2535	6	A Lower Woodbine		
2935-2955	2538-2558	20	A Lower Woodbine		
		10	A Lower Woodbine	2959-2969	2558-2568
		19	A Lower Woodbine	2980-2999	2579-2598

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TABLE 4-8
HISTORICAL INJECTED VOLUME FOR WDW-117

Date/Year	Volume Injected (gallons)
7/11/74 to 12/31/74	1,485,750
1975	9566788
1976	9939826
1977	12539485
1978	9751800
1979	15710800
1980	14957600
1981	13959600
1982	15816000
1983	15808000
1984	24813492
1985	26204283
1986	23076808
1987	19737982
1988	21888750
1989	21657608
1990	21001056
1991	30145275
1992	30716102
1993	21052000
1/1994 to 4/94	8437000
TOTAL	368,266,005

TABLE 4-9
CONSTITUENTS IN THE WDW-394 WASTE STREAM

Constituent/Property	Injection Water
Appearance	Turbid
pH	5-11
Quaternary Ammonium Chloride	5,000 mg/l
Total Residue, 105' C.	5,000 mg/l
Suspended Matter: Total Fixed Volatile	100 mg/l
Settleable Matter	100 mg/l
Immediate Oxygen Demand	2 mg/l
BOD, 5-day, 20'C. (Seeded)	10,000 mg/l
COD (Ag_2SO_4 + $HgSO_4$ Method)	30,000mg/l
Chloride, Cl	65,000 mg/l
Sulfate, SO_4	2,000 mg/l
Oil & Grease	100 mg/l
Ammonia Nitrogen	50,000 ppm
Arsenic; As	<5.0 mg/l
Barium; Ba	50 mg/l
Cadmium; Cd	<1.0 mg/l
Chromium; Cr	<5.0 mg/l
Lead; Pb	<5.0 mg/l
Mercury; Hg	<0.2 mg/l
Selenium; Se	<1.0 mg/l
Silver; Ag	<5.0mg/l
Nickel; Ni	<10 mg/l
Zinc; Zn	10 mg/l

FIGURES